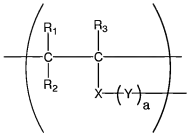
CLAIMS

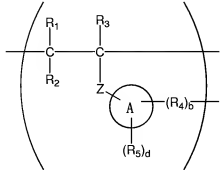
1. A multi-branched polymer having repeating units represented by a formula (I):



. . . (I)

wherein R_1 to R_3 each independently represents hydrogen or a hydrocarbon group, R_1 may be bonded to R_3 to form a ring; X represents a connecting group having a valence of 3 or higher; Y may be the same or different and each represents a functional group which may have an active halogen atom; and a is an integer of 2 or larger.

2. The multi-branched polymer according to claim 1, wherein the repeating units represented by the formula (I) are repeating units represented by a formula (II):



. . . (II)

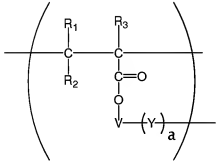
wherein R_1 to R_3 are as defined above; Z represents a single bond or a connecting group having a valence of 2 or higher; A represents an aromatic hydrocarbon group or an aromatic heterocyclic group; R_4 may be the same or different and each represents a functional group which may have an active halogen atom; b is an integer of 2 or larger; R_5 represents a halogen atom or an organic group and d is 0 or an integer of 1 or larger and R_5 may be the same or different when d is 2 or larger.

3. The multi-branched polymer according to claim 2, wherein in the formula (II), Z is a single bond; A is an aromatic hydrocarbon ring; and R_4 is a functional group represented by a formula (III):

$\cdots$ (III)

wherein R_6 and R_7 each independently represents hydrogen, a halogen atom, an alkyl group which may have a substituent, or a linkage with other repeating units with a proviso that R_6 and R_7 do not become linkages with other repeating units at the same time.

4. The multi-branched polymer according to claim 1, wherein the repeating units represented by the formula (I) are repeating units represented by a formula (IV):



$\cdots$ (IV)

wherein R_1 to R_3, Y, and a are as defined above; and V represents a connecting group having a valence of 3 or higher.

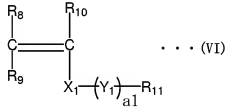
5. The multi-branched polymer according to claim 4, wherein V is a polyoxyalkylene group in the formula (IV).

6. The multi-branched polymer according to claim 4 or 5, wherein in the formula (IV), Y is a functional group represented by a formula (V):

· · · (V)

wherein R_{61} and R_{71} each independently represents hydrogen, a halogen atom, an alkyl group which may have a substituent, or a linkage with other repeating units with a proviso that R_{61} and R_{71} do not become linkages with other repeating units at the same time.

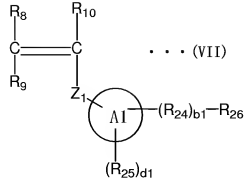
7. A multi-branched polymer obtained with a living radical polymerization method using a metal catalyst by polymerizing compounds represented by a formula (VI):



· · · (VI)

wherein R_8 to R_{10} each independently represents hydrogen or a hydrocarbon group, and R_8 may be bonded to R_{10} to form a ring; X_1 represents a connecting group having a valence of 3 or higher; Y_1 may be the same or different and each represents a functional group which may have an active halogen atom; a1 is an integer of 2 or larger; and R_{11} represents a chlorine atom, a bromine atom, or an iodine atom.

8. The multi-branched polymer according to claim 7, wherein the compounds represented by the formula (VI) are compounds represented by a formula (VII):



· · · (VII)

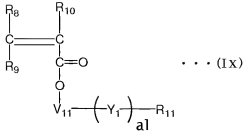
wherein R_8 to R_{10} are as defined above; Z_1 represents a single bond or a connecting group having a valence of 2 or higher; A1 represents an aromatic hydrocarbon group or an aromatic heterocyclic group; R_{24} may be the same or different and each represents a functional group which may have an active halogen atom; b1 is an integer of 2 or larger; R_{25} represents a halogen atom or an organic group and d1 is 0 or an integer of 1 or larger and R_{25} may be the same or different when d1 is 2 or larger; R_{26} represents a chlorine atom, a bromine atom, or an iodine atom.

9. The multi-branched polymer according to claim 8, wherein in the formula (VII), Z_1 is a single bond, A1 is an aromatic hydrocarbon group, and R_{24} is a functional group represented by a formula (VIII):

· · · (VIII)

wherein R_{60} and R_{70} each independently represents hydrogen, a halogen atom, or a C1 to C6 alkyl group which may have a substituent with a proviso that R_{60} and R_{70} are not halogen atoms other than fluorine atoms at the same time.

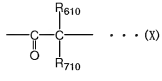
10. The multi-branched polymer according to claim 7, wherein the compounds represented by the formula (VI) are compounds represented by a formula (IX):



wherein R_8 to R_{10} are as defined above respectively; V_{11} represents a connecting group having a valence of 3 or higher; Y_1 may be the same or different and each represents a functional group which may have an active halogen atom; a1 is an integer of 2 or larger; and R_{11} represents a chlorine atom, a bromine atom, or an iodine atom.

11. The multi-branched polymer according to claim 10, wherein V_{11} is a polyoxyalkylene group in the formula (IX).

12. The multi-branched polymer according to claim 10 or 11, wherein in the formula (IX), Y_1 is a functional group represented by a formula (X):



wherein R_{610} and R_{710} each independently represents hydrogen, a halogen atom, an alkyl group which may have a substituent, or a linkage with other repeating units with a proviso that R_{610} and R_{710} do not become linkages with other repeating units at the same time.

13. The multi-branched polymer according to claim 1or 7, wherein a ratio (Mw/Mn) of weight average molecular weight (Mw) to number average molecular weight (Mn) of the polymer is in a range between 1.01 and 9.99.

14. The multi-branched polymer according to claim 1or 7, wherein the number average molecular weight (Mn) of the polymer is in a range between 200 and 20,000,000.

15. The multi-branched polymer according to claim 1or 7, wherein the multi-branched polymer is a hyperbranched polymer.

16. A hyperbranched polymer which is branched by a carbon-carbon bond and has a ratio (Mw/Mn) of weight average molecular weight (Mw) to number average molecular weight (Mn) in a range between 1.01 and 9.99.

17. A hyperbranched polymer obtained by polymerizing a compound having 2 or more polymerization-initiation sites and polymerizable unsaturated bonds by a living radical polymerization method using a metal catalyst.

18. The hyperbranched polymer according to claim 16 or 17, wherein the number average molecular weight (Mn) of the polymer is in a range between 200 and 20,000,000.

19. The hyperbranched polymer according to claim 16or 17, wherein the polymer has a functional group at a polymer terminal.

20. A star polymer having the multi-branched polymer according to claim 1 or 7 or the hyperbranched polymer according to claim 16 or 17 as a core thereof.